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<tr>
<th><strong>Docket Number:</strong></th>
<th>19-IEPR-03</th>
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<tr>
<td><strong>Project Title:</strong></td>
<td>Electricity and Natural Gas Demand Forecast</td>
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<tr>
<td><strong>TN #:</strong></td>
<td>230885</td>
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<tr>
<td><strong>Document Title:</strong></td>
<td>Revised Transportation Energy Demand Forecast</td>
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<tr>
<td><strong>Description:</strong></td>
<td>Transportation Forecast Presentations by: Mark Palmere, Bob McBride and Aniss Bahreinian of CEC</td>
</tr>
<tr>
<td><strong>Filer:</strong></td>
<td>Raquel Kravitz</td>
</tr>
<tr>
<td><strong>Organization:</strong></td>
<td>California Energy Commission</td>
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<td><strong>Submitter Role:</strong></td>
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Revised Transportation Energy Demand Forecast

IEPR Workshop on Revised California Energy Demand Forecast

December 2, 2019

Transportation Energy Forecasting Unit
Demand Analysis Office
Energy Assessments Division
Presentation Outline

• Light duty vehicles
• Medium and heavy duty vehicles
• Overall fuel consumption
Transportation Energy Demand Modeling Uses both Base Year and Projected Inputs

Base year (2017) values
- Vehicle stock by sector, size class and fuel type (DMV, CARB’s 2017 EMFAC, NTD, Staff)
- Household type distribution (2017 ACS, Staff)
- Fuel consumption (BOE, Staff)
- VMT (Caltrans, 2017 NHTS, 2017 CalVIUS, Staff)

Projected Inputs (2018-2030)
- Economic & Demographic data (Moody’s, DOF, Staff)
- Energy prices (EIA, Staff)
- Vehicle attributes (Contractor, Staff)
- Transit & School Bus Population (Clean transit regulations, Staff)
Transportation Demand Forecasting Scenarios are Electricity-Based

<table>
<thead>
<tr>
<th>Demand Case</th>
<th>Population Growth</th>
<th>Income Growth</th>
<th>Fuel Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Petroleum Fuels</td>
</tr>
<tr>
<td>High Demand</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Mid Demand</td>
<td>Mid</td>
<td>Mid</td>
<td>Mid</td>
</tr>
<tr>
<td>Low Demand</td>
<td>Low</td>
<td>Low</td>
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</table>
LIGHT DUTY VEHICLES
## 2019 IEPR Light Duty PEV Scenarios Reflect a Range of Possible Futures

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>ZEV SCENARIOS, 2019</th>
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<tbody>
<tr>
<td><strong>PREFERENCES</strong></td>
<td></td>
</tr>
<tr>
<td>Consumers' ZEV Preference</td>
<td>Low: Constant at 2017 Level, Reference: Increase with ZEV market growth, High: Increase with ZEV market growth, Aggressive: Increase with ZEV market growth, Bookend: Increase with ZEV market growth</td>
</tr>
<tr>
<td><strong>INCENTIVES</strong></td>
<td></td>
</tr>
<tr>
<td>Federal Tax Credit</td>
<td>Decreasing starting 2019, Eliminated after 2022, Decreasing starting 2019, Decreasing starting 2019, Decreasing starting 2019</td>
</tr>
<tr>
<td>State Rebate</td>
<td>To 2025, To 2025, To 2025, To 2030 for BEV/FCV, To 2030 for BEV/FCV</td>
</tr>
<tr>
<td>HOV Lane Access</td>
<td>To 2021, To 2023, To 2025, To 2025 for PHEV, to 2030 for BEV/FCV</td>
</tr>
<tr>
<td><strong>ATTRIBUTES</strong></td>
<td></td>
</tr>
<tr>
<td>Vehicle / Battery Price (by 2030)</td>
<td>ZEV prices based on battery price declining to ~$120/kWh, ZEV prices based on battery price declining to ~$100/kWh, ZEV prices based on battery price declining to ~$80/kWh, ZEV prices based on battery price declining to ~$70/kWh, ZEV prices based on battery price declining to ~$62/kWh</td>
</tr>
<tr>
<td>Max Range (Midsize, 2030)</td>
<td>~312 miles, ~312 miles, ~313 miles, ~313 miles, ~313 miles</td>
</tr>
<tr>
<td>Refuel Time (2030)</td>
<td>15 - 21 min, 15 - 21 min, 10 - 16 min, 10 - 16 min, 10 - 16 min</td>
</tr>
<tr>
<td>Time to Station (2030)</td>
<td>7 - 8 min, Same as gasoline, Same as gasoline, Same as gasoline by 2025, Same as gasoline by 2025</td>
</tr>
<tr>
<td><strong>FORECAST RESULTS</strong></td>
<td></td>
</tr>
<tr>
<td>2030 ZEV Population</td>
<td>2.7 million, 3.7 million, 4.4 million, 5.2 million, 5.6 million</td>
</tr>
</tbody>
</table>
Total LDV Stock Increases With Income and Population

Light Duty Vehicle Stock

- Low
- Mid
- High

Years: 2019 to 2030

Millions

- 30
- 31
- 32
- 33
- 34
- 35
- 36
ZEV and PEV Penetration is Forecast to Rise Significantly
ZEV and PEV Penetration is Forecast to Rise Significantly
BEV Stock Increases to as High as Ten Percent of Total Vehicle Stock

Revised Light Duty BEV Stock
PHEV Stock Grows Significantly, but at a Slower Rate than BEVs

Revised Light Duty PHEV Stock
BEVs Continue to Overtake PHEVs in Popularity During Forecast

Revised PEV Stock by Technology Distribution, Mid Case
Fuel Cell Vehicle Stock Shows Significant Growth in Mid and High Cases

Revised Light Duty FCEV Stock
MEDIUM AND HEAVY DUTY VEHICLES
Outline

• Overview of ZEV MHD Truck Scenarios
• Transit, airport shuttle, and school buses
• Trucks
  – Data changed from preliminary truck forecast
  – Incentive assumptions for trucks vary by scenario
  – MHD truck market share analysis
  – Purchases
  – ZEV MHD truck purchases and counts
MHD Vehicle Classes

**Class 3 - 10,001 to 14,000 lbs**
- Walk-in
- Box Truck
- City Delivery
- Heavy-Duty Pickup

**Class 4 - 14,001 to 16,000 lbs**
- Large Walk-in
- Box Truck
- City Delivery

**Class 5 - 16,001 to 19,500 lbs**
- Bucket Truck
- Large Walk-in
- City Delivery

**Class 6 - 19,501 to 26,000 lbs**
- Beverage Truck
- Single-Axle
- School Bus
- Rack Truck

**Class 7 - 26,001 to 33,000 lbs**
- Refuse
- Furniture
- City Transit Bus
- Truck Tractor

**Class 8 - 33,001 lbs & Over**
- Cement Truck
- Truck Tractor
- Dump Truck
- Sleeper
## 2019 MHD Truck Scenarios

### Inputs

<table>
<thead>
<tr>
<th>CALIFORNIA REGULATIONS</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARB Regulations</td>
<td>Applied to urban transit bus and shuttle bus, implicit for current truck rules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVIP (through 2021)</td>
<td>99% of current HVIP voucher percentage of vehicle incremental cost*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVIP (from 2022 on)</td>
<td>No Incentives</td>
<td>80% of the above</td>
<td>Same as above</td>
</tr>
</tbody>
</table>

### Incentives

<table>
<thead>
<tr>
<th>ATTRIBUTES</th>
<th>Low</th>
<th>Mid/High</th>
<th>Mid/High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Pack Price (MHD vehicle, in 2030)**</td>
<td>MHD BET prices based on battery price declining to $158/kWh</td>
<td>BEV prices based on battery price declining to $131/kWh</td>
<td>BEV prices based on battery price declining to $106/kWh</td>
</tr>
<tr>
<td>MPG</td>
<td>Low</td>
<td>Mid/High</td>
<td>Mid/High</td>
</tr>
<tr>
<td>Truck Range of Operation</td>
<td>For classes 3 to 6, purchased trucks with typical trips under 100 miles can choose battery-electric; for in-state tractor-trailers, trips within the Urban regions are given this choice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Forecast

<table>
<thead>
<tr>
<th></th>
<th>2030</th>
<th>2030</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery electric stock</td>
<td>11,977</td>
<td>77,345</td>
<td>100,221</td>
</tr>
<tr>
<td>Catenary Electric Stock</td>
<td>262</td>
<td>624</td>
<td>5,294</td>
</tr>
<tr>
<td>Hydrogen fuel cell stock</td>
<td>365</td>
<td>389</td>
<td>13,356</td>
</tr>
<tr>
<td>Total ZEV stock</td>
<td>12,604</td>
<td>78,358</td>
<td>118,871</td>
</tr>
</tbody>
</table>

* -- incremental cost is the difference between the purchased truck and the least expensive truck in the class

** -- MHD battery price assumed about 30% higher than LDV battery, due to cost of built-in resilience to more intensive drive cycles
Transit, Airport Shuttles, and School Buses, High Case

- ZEV transit and airport shuttle buses are based on regulations
- ZEV school buses are based on funding availability

<table>
<thead>
<tr>
<th>ZEV Bus Population in 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Buses</td>
</tr>
<tr>
<td>Airport Shuttles</td>
</tr>
<tr>
<td>School Buses</td>
</tr>
</tbody>
</table>
MEDIUM- AND HEAVY-DUTY TRUCKS
Changes in Revised MHD Forecast

- Reduced the battery cell prices for battery-electric trucks by assuming the price is 30% higher than LDV battery cell price
- Fleets choosing a fuel technology for new trucks now consider a higher annual VMT, making alternative fuels more likely
- Truck retirement by age is now three distinct cases
- Hydrogen fuel is changed from the commercial retail price to a dedicated fleet price for the high demand case
  - Higher station utilization by dedicated fleets
  - Lower tank pressure for large trucks
MHD Incentives Assumed for Revised Forecast

• Using CARB’s recent* HVIP voucher through 2021, which is a percent of the truck’s incremental cost
  – Covers ZEV, natural gas, and diesel-electric hybrid*
  – Varies by fuel and truck class: ZEV near 100%, low NOx lower
  – Assumes funding is available for all purchases through 2021
• From 2022 - 2030, ZEV voucher is assumed to be:
  – High case: 99% of the incremental cost
  – Mid case: 80% of the recent voucher amount
  – Low case: no incentive

* ARB to discontinue hybrid and Low NOx voucher, except 12 liter Low NOx engine
GVWR 3 Medium-duty Truck & Van Market Share (10,001 to 14,000 pounds gross weight)
In-state Tractor-trailers Consume the Most California Fuel

Red bars represent GVWR 4 to 8 straight trucks subject to 50% manufacturer ZEV production requirement by 2030 under proposed Advanced Clean Truck regulation (CARB). Blue bars identify 15% manufacturer ZEV production requirement by 2030.
Emerging ZEV Tractor-trailers
Fuel Cost per Mile
Mid and High Cases, In-state Tractor-trailer

**Mid Case**

- electric
- natural gas
- hydrogen
- direct electric

**High Case**

- electric
- natural gas
- hydrogen
- direct electric

Year: 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030

Cost Range: $0.00 to $0.90
Dedicated Fleets on the Rise?
Short or Longer Term Change?

## EXHIBIT 1
**One-Way vs. Dedicated Truckload Fleet Growth: 2017 to 2018**

<table>
<thead>
<tr>
<th>Carrier</th>
<th>One-Way Truckload</th>
<th>Dedicated Truckload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Truck Count</td>
<td>% Change</td>
</tr>
<tr>
<td>Marten</td>
<td>1,837, 1,613</td>
<td>-12.2%</td>
</tr>
<tr>
<td>Schneider</td>
<td>7,930, 7,651</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Swift</td>
<td>9,419, 7,484</td>
<td>-20.5%</td>
</tr>
<tr>
<td>U.S. Xpress</td>
<td>3,788, 3,562</td>
<td>-6.0%</td>
</tr>
<tr>
<td>Universal Truckload Services</td>
<td>1,950, 1,787</td>
<td>-8.4%</td>
</tr>
<tr>
<td>Werner</td>
<td>3,483, 3,345</td>
<td>-4.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28,407, 25,442</td>
<td>-10.4%</td>
</tr>
</tbody>
</table>

**SOURCE:** COMPANY REPORTS
**CHART PREPARED BY SJ CONSULTING GROUP INC.**

Truck Market Share, In-state Tractor-trailer

**Mid Case**

**High Case**

- **electric**
- **natural gas**
- **diesel**
- **hydrogen**
- **direct electric**
New MHD Truck Purchases (All Classes)
Freightliner eCascadia and eM2; Volvo VNR Electric
Considering ZEV Tractor-trailer Announced Prices

• We tested prices announced by Nikola and Tesla
  – Battery electric and hydrogen fuel cell trucks would achieve a significant market share at the prices announced for the Tesla Semi and Nikola Two
  – However, there is uncertainty around these announced prices
• We used bottom-up component-based price estimates
• High case incentives cover 99% of incremental cost for ZEV, regardless
Hydrogen Fuel Cell Tractor-trailer

- Retail hydrogen prices are too high for hydrogen fuel cell to compete with other fuels
- Introduced a high case hydrogen price based on two factors that support a $5 to $7 per Kg price for dedicated fleets:
  - Tank pressure of 5,000 psi instead of 10,000 psi bring savings on tank and compression
  - Dedicated-route fleets can ‘right-size’ each station, increase their utilization
- Nikola Motors plans fleet and fuel station in Los Angeles area in 2021
  - Iveco Truck (European OEM) partnered with Nikola Motors (Sept. 2019)
    “IVECO is a huge global player and this shows, more and more, that Nikola is a serious company,” Antti Lindström, IHS Markit, told Trucks.com.”
- Toyota – Kenworth HFC and Hyundai HD trucks also anticipated

Sources: Nikola Motors; Toyota Motor NA; CA FC Partnership; trucks.com
MHD ZEV Stock Forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>Low</th>
<th>Mid</th>
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<tbody>
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<td>2019</td>
<td>50</td>
<td>60</td>
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</tr>
<tr>
<td>2020</td>
<td>60</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>2021</td>
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<tr>
<td>2030</td>
<td>160</td>
<td>170</td>
<td>180</td>
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</tbody>
</table>
REVISED TRANSPORTATION ENERGY DEMAND
# Fuel Types and Vehicle Types

## 2017 Diesel & Gasoline Fuel Types & Vehicle Types Share by Vehicle Type

### Fuel Types & Vehicle Types

<table>
<thead>
<tr>
<th></th>
<th>LDV Up to 10,000 lb</th>
<th>MHDV &gt;10,000 lb</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>Gasoline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline Hybrid</td>
<td>Gasoline Hybrid</td>
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</tr>
<tr>
<td>Flex Fuel Vehicle (E85)</td>
<td>Dedicated E85</td>
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</tr>
<tr>
<td>Diesel</td>
<td>Diesel</td>
<td>Diesel</td>
<td>Diesel</td>
</tr>
<tr>
<td>Diesel Hybrid</td>
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<td>Diesel Hybrid</td>
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</tr>
<tr>
<td>BEV</td>
<td>BEV</td>
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</tr>
<tr>
<td>PHEV</td>
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<td>Direct Electric</td>
<td>Direct Electric</td>
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<td>FCEV</td>
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<td>FCEV</td>
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</tr>
<tr>
<td>PHFCV</td>
<td></td>
<td></td>
<td>CNG</td>
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<td></td>
<td>LNG</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Propane</td>
</tr>
</tbody>
</table>

### Diagram

- **LDV (Up to 10,000 lb):**
  - Gasoline: 71%
  - Diesel: 26%
  - Gasoline Hybrid: 2%

- **MHDV (>10,000 lb):**
  - Gasoline: 89%
  - Diesel: 26%
  - Gasoline Hybrid: 2%
Revised High Transportation Fuel Demand Forecast by Fuel Type (Gasoline Gallon Equivalent, or GGE)
2030 High Demand Forecast

Alternative Fuels by Fuel Type

Electricity Demand Distribution by Vehicle Type

- Electricity
- E85
- Hydrogen
- Natural gas
- Propane

- LDV
- MHD
- Rail
Revised Transportation Electricity Demand Forecast by Scenario
Revised Transportation Hydrogen Demand Forecast
Revised Transportation Natural Gas Demand Forecast
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– Sudhakar Konala, ZEV Attributes
  • Sudhakar.Konala@energy.ca.gov
Appendix
LIGHT DUTY VEHICLE STOCK
Gasoline Vehicle Stock Begins Steadily but Shows Increases by End of Forecast

Revised Light Duty Gasoline Stock

Millions

<table>
<thead>
<tr>
<th>Year</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
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<tbody>
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<tr>
<td>2030</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
</tr>
</tbody>
</table>
Flex-Fuel Vehicle Stock Shows Short Term Increases but Levels Off by End of Forecast

Revised Light Duty FFV Stock

- Low
- Mid
- High
Diesel Stock is Steady in Short Term but Increases in the Longer Forecast

Revised Light Duty Diesel Stock
Hybrid Vehicle Stock Scenarios are Very Similar

Revised Light Duty Hybrid Stock

<table>
<thead>
<tr>
<th>Year</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
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<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>2020</td>
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<tr>
<td>2030</td>
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</tbody>
</table>
TRANSIT, AIRPORT SHUTTLES, AND SCHOOL BUSES
New MHD Bus Purchases: Transit, School, and Shuttle buses

![Chart showing thousands of vehicles purchased from 2017 to 2030]
Innovative Clean Transit Regulations

• January 1, 2020: new conventional internal combustion engine bus or hybrid bus purchases must have low-NOx engines

• Large transit agencies must purchase a minimum number of zero-emission buses in each calendar year
  • 2023: 25% of the total number of new bus purchases
  • 2026: 50% of the total number of new bus purchases
  • 2029: 100% of the total number of new bus purchases

• Small transit agencies have a delayed schedule
Zero Emission Transit Bus Purchases Based on ICT Regulations

- High electricity demand
- Mid
- Low electricity demand
- ICT regs only, no credits
Zero Emission Airport Shuttle
Purchase Requirements Based on Regulation

- Shuttle operators in 13 regulated airports must purchase a minimum number of zero emission shuttles in each calendar year listed below
  - 2027: 33% of fleet must be zero emission
  - 2031: 66% of fleet must be zero emission
  - 2035: 100% of fleet must be zero emission
- Starting in 2023, a zero emission shuttle can be only replaced with another zero emission shuttle
- Exemptions and Extensions:
  - Shuttles that operate less than 3,000 miles per year are defined as “reserve” and are not included in calculating the ZEV fleet percentage
  - Extensions will be granted to applicants with unforeseen circumstances such as natural disasters or inadequate charging/fueling infrastructure
Electric School Buses

Purchases are based on funding availability
School Bus Stock by Fuel

Thousands

- Diesel
- Natural Gas
- Propane
- Gasoline
- Hybrid
- Electric

Years:
2019 - 2030
BATTERY ELECTRIC AND FUEL CELL TRUCK STOCK
Electric Truck Stock Forecast
(includes battery and catenary electric)
Hydrogen Fuel Cell Truck Stock Forecast

Thousands of Vehicles


- Low
- Mid
- High
FUEL CONSUMPTION
Revised High Alternative Fuel Demand Forecast, by Fuel Type (GGE)
Revised High Electricity Demand by Sector (GGE)

Electricity

- LDV
- MHD
- Rail
Revised Gasoline Demand Forecast

Billions of Gasoline Gallons

- Low
- Mid
- High

- 2018
- 2020
- 2022
- 2024
- 2026
- 2028
- 2030
- 2032
Revised Diesel Demand Forecast

Chart Title

Billions of Diesel Gallons

2018 2020 2022 2024 2026 2028 2030 2032

Low  Mid  High
Revised Jet Fuel Demand Forecast

- **Billions of Gallons**

  - Low
  - Mid
  - High

  - Years: 2018 to 2032
Revised E85 Demand Forecast

![Graph showing the forecast for E85 demand from 2018 to 2032, with data points for low, mid, and high scenarios.]
Revised Propane Demand Forecast
MHD Truck Consumption of Diesel Plus Gasoline

![Graph showing MHD truck consumption of diesel plus gasoline over time with lines for different scenarios. The graph indicates a decreasing trend in gallons consumed from 2019 to 2030.]